Chapter 7
Collection and Handling of Low-Level Radioactive Waste

7-1. Introduction

Waste collection and handling methods are discussed in EM 1110-1-502. Waste categories addressed include drums, soils, sediments, and groundwater. The methods discussed below are equally applicable to hazardous wastes and radioactive wastes. As discussed previously, the safety precautions that need to be taken differ.

7-2. Drum Handling

a. Background. Many of the problems with uncontrolled disposal sites can, in part, be considered a result of improper drum disposal. Initial estimates of drum locations and contents should be performed by using historical records and previous site personnel. Since each disposal site is different, selection and implementation of equipment and methods for handling drum-related problems must be independently determined. The primary factors that influence the selection of equipment or methods include worker safety, site-specific variables affecting performance, environmental protection, and costs. Site-specific variables include accessibility of the site, drum integrity, surface topography and drainage, number of drums, depth of burial, and the type of wastes present.

b. Detecting and locating drums. Precise estimates of the locations of drums should be determined through the use of historic and background data, aerial photography, geophysical surveying, and sampling. Geophysical methods used for drum location include magnetometry, metal detectors, ground-penetrating radar, and electromagnetic.

c. Environmental protection. Measures to prevent contaminant releases should be practiced at all sites. These include overpacking or pumping the contents of leaking drums. Releases should be contained or mitigated once they have occurred with controls such as perimeter dikes. Uncontrolled mixing of incompatible wastes should be avoided by handling only one drum at a time during excavation. Drum-opening activities should be isolated from staging and working areas. In addition, nonsparking tools and explosion-proof pumps should be used when handling unknown wastes.

d. Drum integrity. The excavation and handling of damaged drums can result in spills which may seriously jeopardize worker safety and public health. Any drum that is critically swollen should not be approached. The drum should be handled only by remotely controlled equipment. Generally a drum is inspected visually to check for corrosion, leaks, swelling, etc. However, worker safety should be stressed during this inspection.

e. Drum opening, sampling, and compatibility. Container opening and sampling should be conducted in an isolated area. Remotely controlled drum opening and sampling techniques should be used when possible. Compatibility testing is required prior to bulking, storing, or shipping of the containers. Compatibility testing should be rapid using onsite procedures for assessing waste reactivity, volubility, presence of oxidizer, water content, acidity, etc.

f. Treatment options. The drums can be overpacked, compacted, contents transferred to new drums, contents removed and treated separately, or contents solidified to facilitate handling.

7-3. Excavation of Contaminated Soils

a. Design considerations. Where offsite treatment methods are to be used, excavation and transportation of the waste material will be required. Important factors that should be considered before beginning excavation are worker exposure and the bearing capacity of the site for heavy equipment. Both USACE and OSHA regulate worker safety in open excavations. The following equipment can be used for excavation:

b. Mechanical methods. Typical excavation equipment includes draglines, backhoes, and clamshells.

(1) Dragline excavator. A dragline excavator is a crane unit with a drag bucket connected by cable to a boom. The bucket is filled by scraping it along the top layer of soil toward the machine by a drag cable. The dragline can operate below and beyond the end of the boom. Maximum digging depth of a dragline is approximately equal to half the length of the boom, while digging reach is slightly greater than the length of the boom. Draglines are very suitable for excavating large land areas with loosely compacted soil.

(2) Backhoes. The backhoe unit is a boom or dipper stick with a hoe dipper attached to the outer end.

The unit may be mounted on either crane-type or tractor equipment. Commonly used backhoes will dig to a maximum depth of about 14 m (45 ft). Deeper digging depth can be achieved by attaching long arms to one-piece booms or by adjusting the boom angle on two-piece booms. Some hydraulic backhoes having booms that can be extended up to 31 m (100 ft) or retracted for close work can be used to excavate, backfill, and grade.

(3) Clamshells. To achieve deeper digging depth, clamshell equipment must be used. A clamshell bucket is attached to a crane by cables. A clamshell excavator can reach digging depths of 15 m (50 ft) or more.

7-4. Excavation of Contaminated Sediments

a. Dredging. Uncontrolled waste disposal sites may contaminate bottom sediments in water bodies. Sediments tend to concentrate pollutants so they may actually be contributing more to the contaminant problem than the water. Dredging serves the same basic function as mechanical excavation. Several types of dredges are commonly used, including hydraulic, pneumatic, and mechanical dredges. A knowledge of the physical properties and distribution of contaminated sediments is essential in selecting a dredging technique and planning the dredging operation. Information on grain size, bed thickness, and source and rate of sediment deposition is particularly useful. Such information can be obtained through a program of bottom sampling or core sampling of the affected sediment. The following equipment can be used for dredging:

b. Hydraulic dredging. Available techniques for hydraulic dredging of surface impoundments include centrifugal pumping systems and portable hydraulic pipeline dredges. Centrifugal pumping systems utilize specially designed centrifugal pumps that cut heavy, viscous materials as pump suction occurs. The special chopper impeller devices within these pumps allow high-volume handling of heavy sludges without the use of separate augers or cutters. Pipeline dredges loosen and pick up bottom material and water and discharge the mixture through a float-supported pipeline to an offsite treatment or disposal area. For larger jobs, a standard butterhead dredge may be required.

c. Low-turbidity hydraulic dredging. Low-turbidity dredging minimizes the resuspension of bottom materials that may occur during the operation. Conventional dredging may cause excessive agitation and resuspension of contaminated sediments, which decreases sediment removal efficiency. This may also lead to downstream transport of contaminated materials, thereby worsening the pollution problem. Low-turbidity dredging systems include conventional dredges that are modified using special equipment for turbidity control.

d. Mechanical dredging. Mechanical dredging of contaminated sediments should be considered under conditions of low, shallow flow. Under any other conditions, mechanical excavation with draglines, clamshells, or backhoes may create excessive turbidity and cause uncontrolled transport of contaminated sediments further downstream. A more efficient mechanical dredging operation is the dewatering of the impoundment followed by excavation.

e. Design considerations. The selection of dredging equipment or pumping systems for the removal of contaminated materials will depend largely on manufacturer specifications for a given dredge vessel or pump system. Important selection criteria that will vary from site to site are:

(1) Surface area and maximum depth of the impoundment.

(2) Total volume of material to be dredged.

(3) Physical, chemical, and radiological nature of sediments.

(4) Pumping distance and total head.

(5) Presence of bottom liner in impoundment.

(6) Type and amount of aquatic vegetation.

(7) Power source for dredge.

(8) Ease of access and size and weight limits of roads.

For additional, detailed information on dredging technology, see EM 1110-2-5025.

7-5. Removal or Isolation of Contaminated Groundwater

a. Wellpoint systems. Two common groundwater pumping systems use either wellpoints or extraction/injection wells. Wellpoint systems use a series of wells in order to lower the water table. The system consists of a group of closely spaced wells, usually connected by a header pipe and pumped by suction centrifugal pumps, submersible pumps, or jet ejector pumps. The drawdown depressions formed by the well network effectively lower the water table. Wellpoint systems are generally used at sites with relatively shallow water tables and fairly permeable soils. The hydraulic gradient, transmissivity, and storage coefficients affect the rate of flow.

b. Extraction/injection well systems. In most cases, contaminated groundwater at waste sites is contained by installing extraction wells to extract groundwater from under the site, collecting contaminants leaking from the waste and creating a local gradient toward the site. Extraction trenches may be economical and more effective than extraction wells in the case of shallow contamination. Trenches offer the advantage of providing a continuous line of catchment compared to a line of wells, though depths are limited in practice and excavation quantities (of potentially contaminated materials) can be large. Whether by well or trench, water withdrawn from under the site will then be treated before disposal or reinfection into the aquifer. This system is also effective for plume containment. An example of an effective system for plume containment is currently operating at the Rocky Mountain Arsenal. Groundwater is extracted, treated, and recharged through injection wells on the downgradient side of an impermeable barrier (slurry wall). The extraction and injection systems are separated by an impermeable barrier to prevent mixing of contaminated and uncontaminated water. As a less costly alternative to recharging water through injection wells, seepage or recharge basins can be used.

c. Subsurface barriers. The most common subsurface barriers are slurry-trench cutoff walls, grout curtains, sheet-pile cutoff walls, membranes and synthetic sheet curtains, and combination barrier/pumping systems.

(1) Slurry-trench cutoff walls. Slurry trenching redirects or impedes groundwater flow. Slurry walls are fixed underground barriers formed by pumping a soil or cement, bentonite, and water mixture into trenches. The soil-bentonite trench filling is produced by backfilling. The cement-bentonite slurry is allowed to set. The slurry used in the soil-bentonite mixture is essentially a 4- to 7-percent by weight suspension of bentonite in water. For the cement-bentonite slurry, a 90-day minimum set time is important. When the slurry wall is placed upgradient of the waste site, it will force the groundwater to flow around the wastes. In certain settings, a slurry wall can be installed to completely surround the site. The groundwater inside can then be extracted and treated. Grades of 10 percent and higher provide problems for slurry wall construction. Groundwater chemistry can severely affect the behavior of the bentonite slurry. Compatibility tests should be performed with the actual leachate from the waste site.

(2) Grout curtains. Grouting consists of the injection of one of a variety of special fluids or particulate grouts into the soil under high pressure. Because a grout curtain can be three times as costly as a slurry wall, it is rarely used when groundwater has to be controlled in soil. The major use of grout curtaining is to seal voids in porous or fractured rock where other methods of groundwater control are impractical. Ninety percent of all the grouting done in the United States is with portland cement. For grouting, a water-cement ratio of 0.6 or less is more effective. Grout curtaining is a very complex operation, with the number of U.S. firms engaged in this practice quite limited. Incompatibility with the groundwater chemistry can cause the same problems here as in slurry wall construction.

(3) Sheet-pile cutoff walls. Sheet-pile cutoff walls constitute a permeable passive barrier composed of sheetpiling permanently placed in the ground. Each section interlocks with an adjacent section by means of a ball/socket union. The connection may initially be a pathway for groundwater migration, which may cease if the section is naturally or artificially filled with impermeable material. Steel sheetpiling is most frequently used. Concrete has been used and is attractive when exceptional strength is required. Sheet-piles are typically used in soils that are loosely packed and predominantly sand and gravel in nature. Maximum effective piling depth is considered to be 15 m (49 ft). A pile life of up to 40 years can be expected where pH ranges between 5.8 and 7.8. A pH as low as 2.3 can shorten the lifetime to 7 years or less. Site characteristics should be investigated thoroughly to determine if the site is compatible with sheetpiling.

(4) Membranes and synthetic sheet curtains. Synthetic membrane materials such as PVC, butyl rubber, and polyethylene can be used in a manner similar to clay or sheet-pile cutoff walls. It is difficult, however, to emplace the curtain without puncture or imperfect sealing. Soil and atmospheric temperatures affect the flexibility as well as the sealing characteristics of the membrane.

(5) Combination barrier/pumping systems. When used in combination, the general approach is to use the barrier system to minimize the quantity of groundwater that must be pumped and treated. The most common application of a combination barrier/pumping system is

the use of a circumferential slurry wall, constructed into an underlying aquiclude, combined with an interior pumping system to maintain an inward hydraulic gradient.

7-6. Decontamination of Equipment

Methods of decontaminating the equipment described in this chapter are given in Chapter 8, Section 8-3.